Aim of the assignment:

We need to create a mask of the areas automatically using Image recognition techniques. The images given to us are from the bullet cartridge. We need to identify the areas as

1. The breech-face impression (red)
2. The firing pin impression (purple)
3. The firing pin drag (light blue)
4. The direction of the firing pin drag (blue arrow)
5. The aperture shear (green)

Assumptions

To approach this problem we need to have some assumptions.

1. All images given are top scans of the cartridges, which gives us uniform image composition, and the cartridges are placed in uniform order concerning the microscope
2. Primer is always placed in the center of the cartridge.

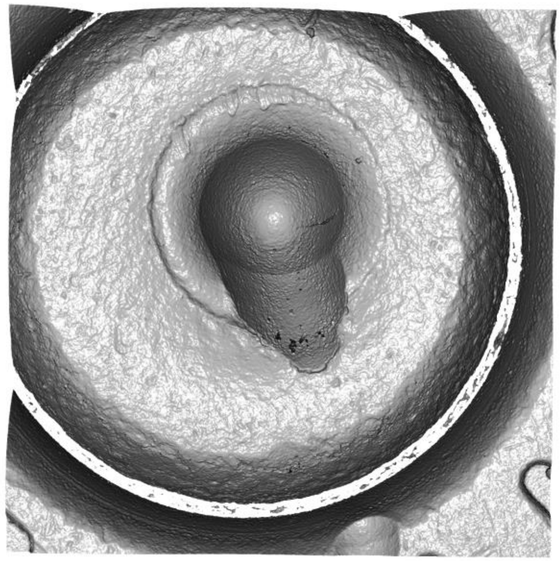
Problem Approach

Let’s divide the problem into 5 parts for 5 different areas we need to mask

1. **Finding the breach face impression**
   For this, I was able to create a Python code that helps in creating the mask of the given image. I used the OpenCV library for this problem because it is one of the best libraries available in Python for image processing and alongside used Numpy for the manipulation of arrays and Matplotlib for the visualization.

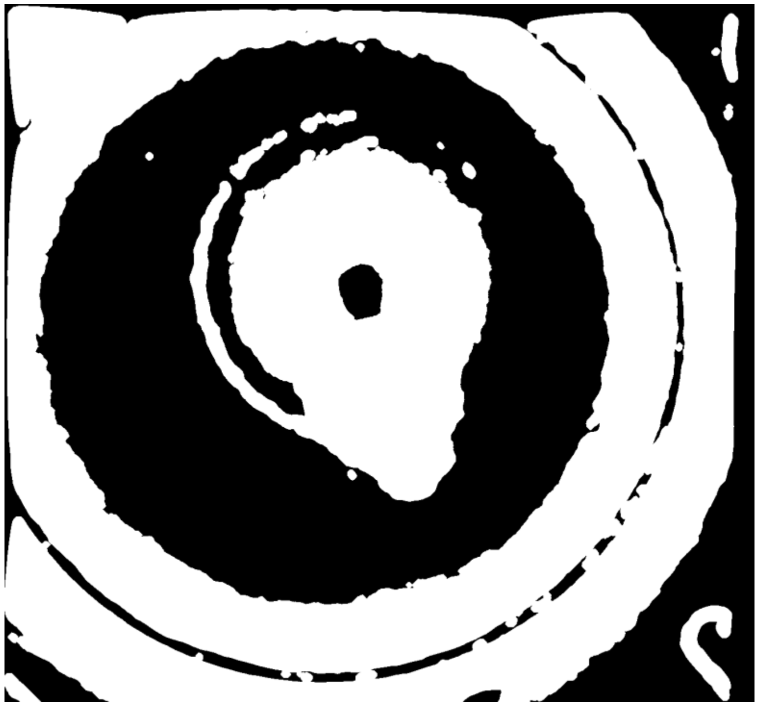
   The

   Steps:
   1. Used the given image by reading it first using the imread function.

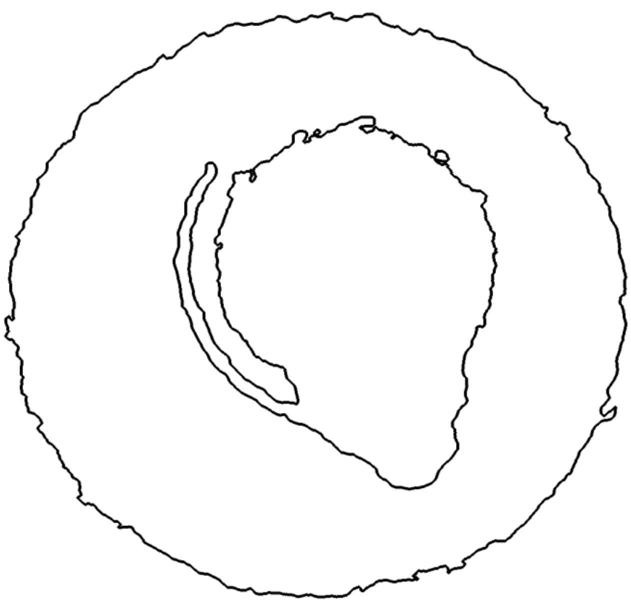


2. Convert the image to greyscale and then to black and white using the threshold function in OpenCV as it helps in identifying the brighter and darker areas.

3. Invert the image to find the contours in the shape as we are interested in finding the breach face.
4. Sort all contours by area in descending order.



5. We are interested in getting the second (C2) and third-largest (C3) contours in the image, as the largest contour would be from the back of the cartridge face.
6. Create a mask of the same shape as the image and draw the contours C2 and C3



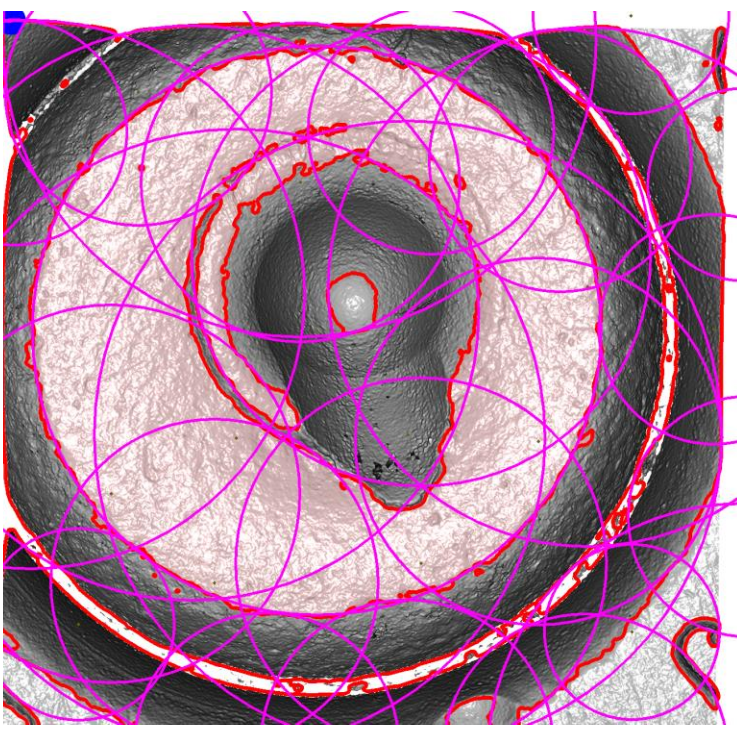
7. This gives us the area of the breech face.
8. Use floodFill function along with minEnclosingCircle to find the seed that lies within the shape.
9. Use this seed to fill the mask, resulting in the breech face mask.

10. Use this Mask over the image to identify the area on the cartridge

2. **Firing Pin Impression**

   This can be achieved by enclosing rectangles of contour and [hough circles](#).

   1. Convert the image to black and white
   2. Find all circles in images using Hough circles.



   3. Identify the largest circle (FaceCircle) in the image as the back face of the cartridge

4. Find the smallest rectangle that encloses the circle FaceCircle and crop the rectangle (FaceRectangle) using boundingRectangle.
5. Reduce the size of FaceRectangle by 20 % to eliminate the boundaries of FaceCircle from the image so that it is not identifiable by Hough Circles.
6. Find all the circles within the FaceRectangle
7. Sort all circles with respect to their distance from the circle center and rectangle center.
8. Using the assumption that the firing pin is in the center of the cartridge, find the circle whose center lies closest to the rectangle center. This circle (Primer Circle),which represents the Primer.
9. Crop the Primer Circle using the rectangle method.
10. Identify the largest circle within Primer Circle to obtain the Firing Pin impression
11. Create a mask of the impression (Impression Mask).

The Purple part is the Firing Pin Impression

3. **Firing Pin Drag**

Using the result found out in Solution 1 we can find the firing pin drag.

1. Let's take the mask from Solution 1, the white part in the middle contains the firing pin impression and firing pin drag.
2. Remove the Firing pin impression mask from the breech face mask to obtain the Firing Pin Drag mask.

4. **The Direction of the Firing Pin Drag**

1. Find the biggest contours of both the firing pin impression and firing pin drag
2. Create an enclosing rectangle for both of these contours and find the center of each rectangle.

3. Determine the direction from the center of the Firing Pin Impression to the Firing Pin Drag, which gives us the Direction of the Firing Pin Drag.

I also found a research paper that researched on automated detection of regions of interest in cartridge case images using deep learning. They used 2d images and around 1195 samples. A few key points were of great importance in that paper:

- The study focuses on the automated segmentation of ROI (Region of Interest) on cartridge case images using deep learning (U-Net) for improved ROI detection, specifically for the breech face and firing pin impressions.
- The firing process of a gun transfers characteristic marks to the cartridge case, including the firing pin (FP) and breech face (BF) impressions, each with specific shapes and delimiters.
- The study used U-Net deep-learning architecture for segmentation and commonly used metrics such as Intersection over Union (IoU) and Dice Coefficient (DC) for evaluating the models.
- The data set was split into training, validation, and test sets, and augmented training and validation sets were created using random transformations.
- Two final models were trained for both regions of interest (BF and FP) using the original and augmented data sets, achieving high performance in terms of IoU and DC.
- The study proposes using segmentation predictions to detect misplaced delimiters in databases and suggests further work to assess the method's performance compared to traditional methods and to create new masks with perfect circles positioned over the predicted ROI.
- Future work could involve additional metrics, optimization, and training of models using other images and exploring the use of images from different calibers of firearms to add more flexibility to the tool.

Future Work:

If we had more data samples we could evaluate different positions and also put in the concept of deep learning and machine learning algorithms to test and train the models.
A modern deep-learning approach could evaluate the positioning of circular delimiters in cartridge case images and eventually help identify images with suboptimal circular delimiters in ballistic sample databases.
An alternative approach involves generating a new mask by identifying contours on the predicted Region of interest and subsequently drawing precise circles that align with the natural outlines of the segmented shapes. This process entails contour detection on the predicted masks, followed by extracting coordinates for the points belonging to these contours.